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Modeling Navigation Channel Infilling and Migration at Tidal Inlets:

Sensitivity To Waves And Tidal Prism

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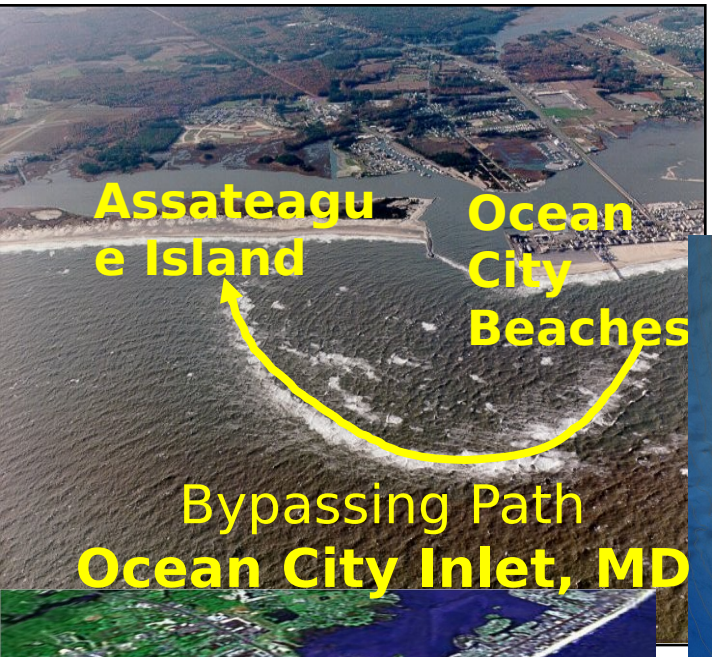
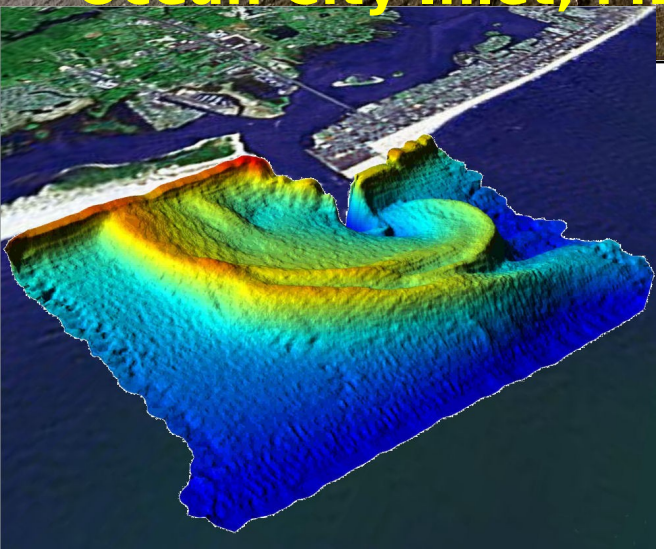
CIRP Mission Support Technology Transfer Research & Development

CHL Coastal and Hydraulics Laboratory

Morphologic Features of Navigable Tidal Inlets





Presentation Overview

- Discussion of Scope and Methods
- Presentation of some of the results obtained
- Concluding remarks and significance of findings

Scope and Methods

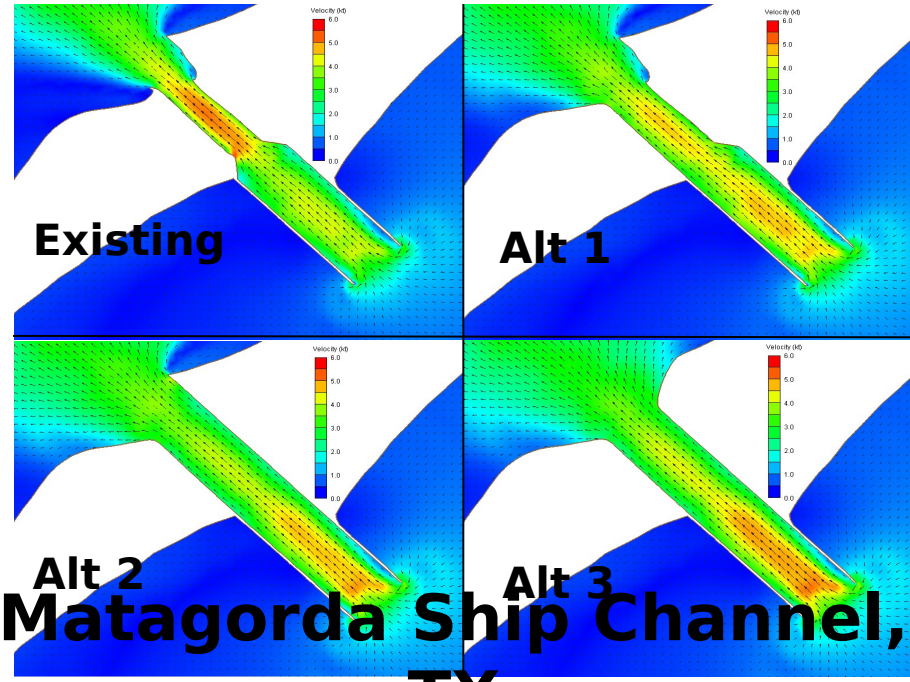
- Idealized simulations to examine 1st-order effects
- Varied channel-bar systems
- Sensitivity to wave forcing
- Sensitivity to tidal prism forcing

Coastal Modeling System (CMS)

2-D and 3-D Numerical modeling at local- to regional-scale

coastal projects including:

- Inlets
- Navigation channels
- Coastal structures

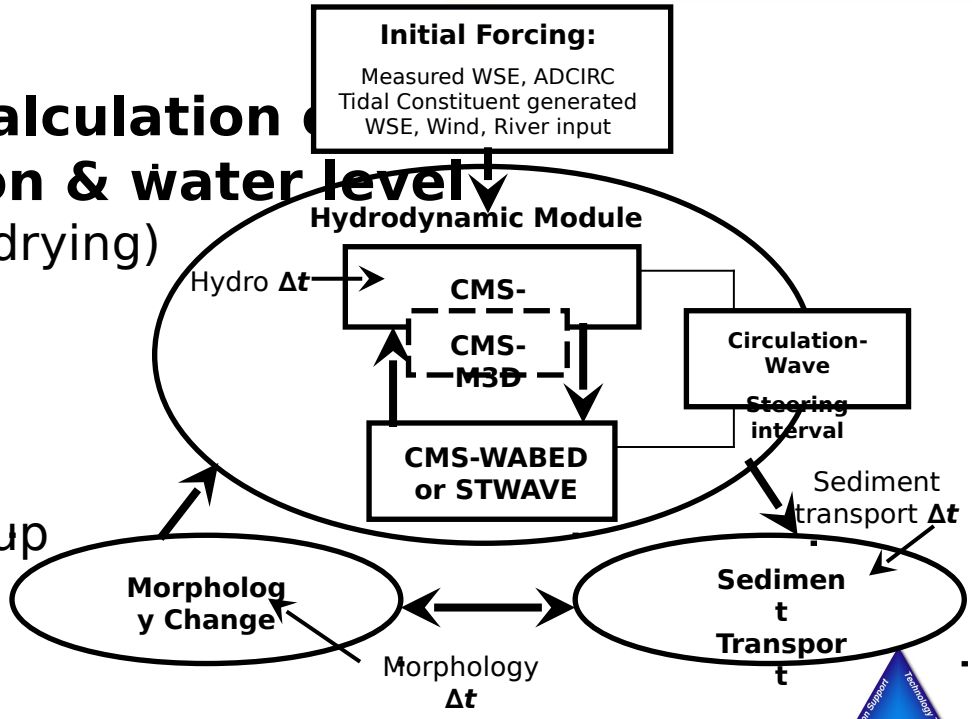


Matagorda Ship Channel, TX

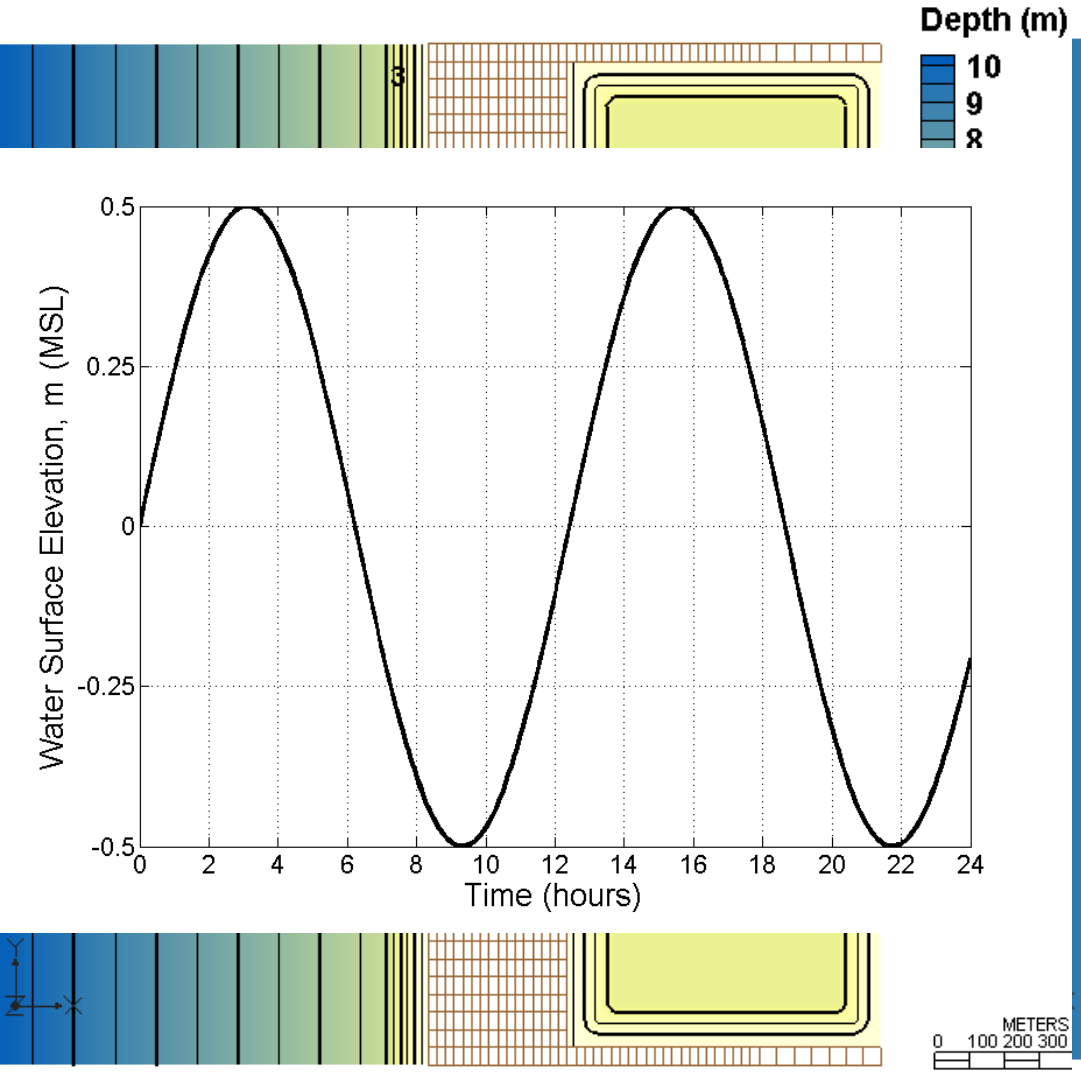
Flood Current analysis of design alternatives

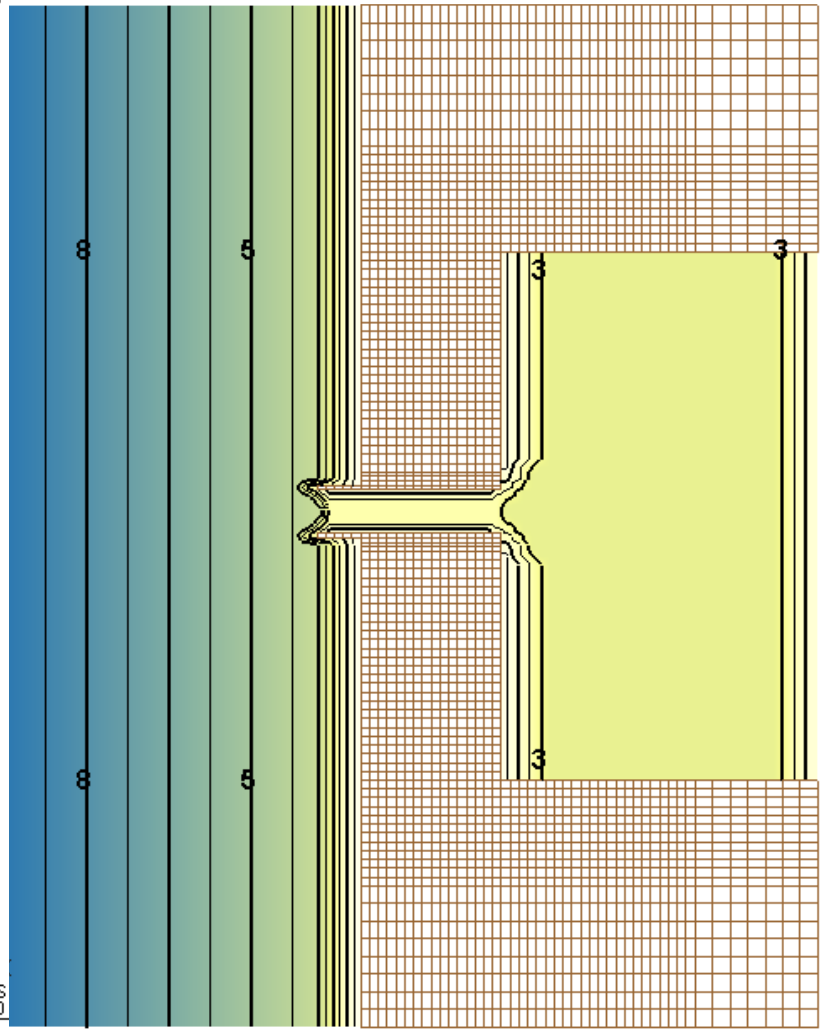
CMS Capabilities

- **CMS model interconnectivity - all supported within the SMS interface:**
  - **CMS-M2D** (w/explicit and implicit modes)
  - **CMS-WABED**
  - **CMS-M3D**
  - STWAVE
  - ADCIRC
- **Efficient, high-resolution calculation**
  - **Hydrodynamic circulation & water level**
    - Tide (including flooding & drying)
    - Waves
    - Wind forcing
    - Flow from river input
    - Advection
    - Storm surge and wave setup
  - **Sediment Transport**
  - **Geomorphic evolution**
  - **Salinity**

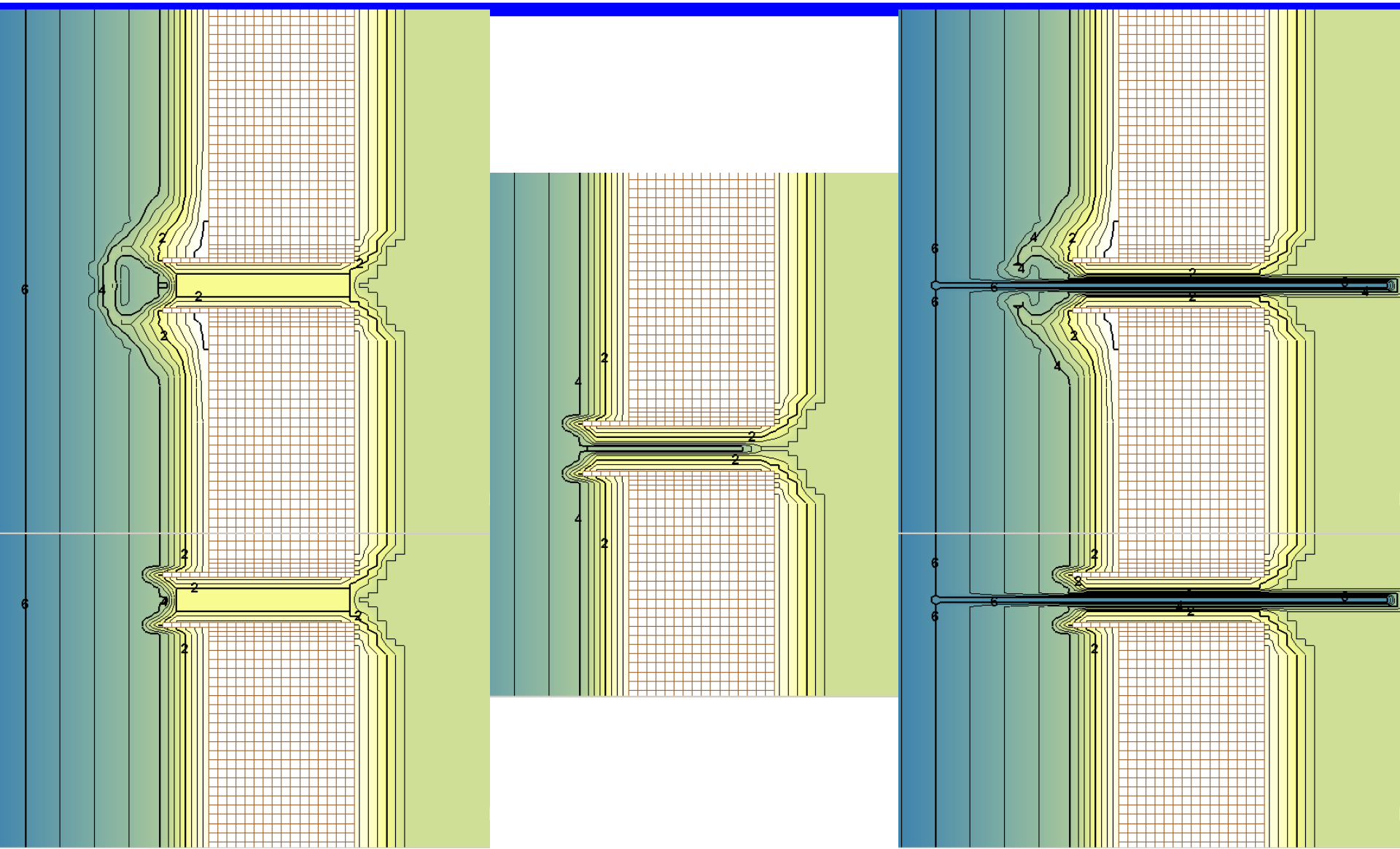


Model Domain





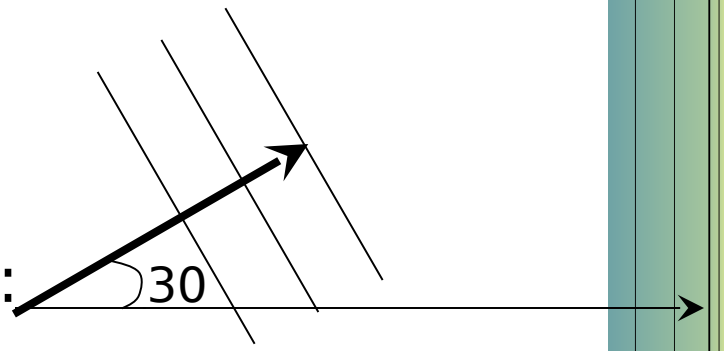
Initial Channels

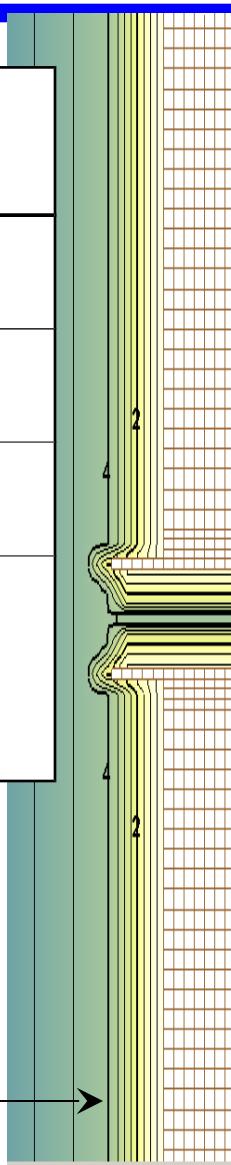


Waves

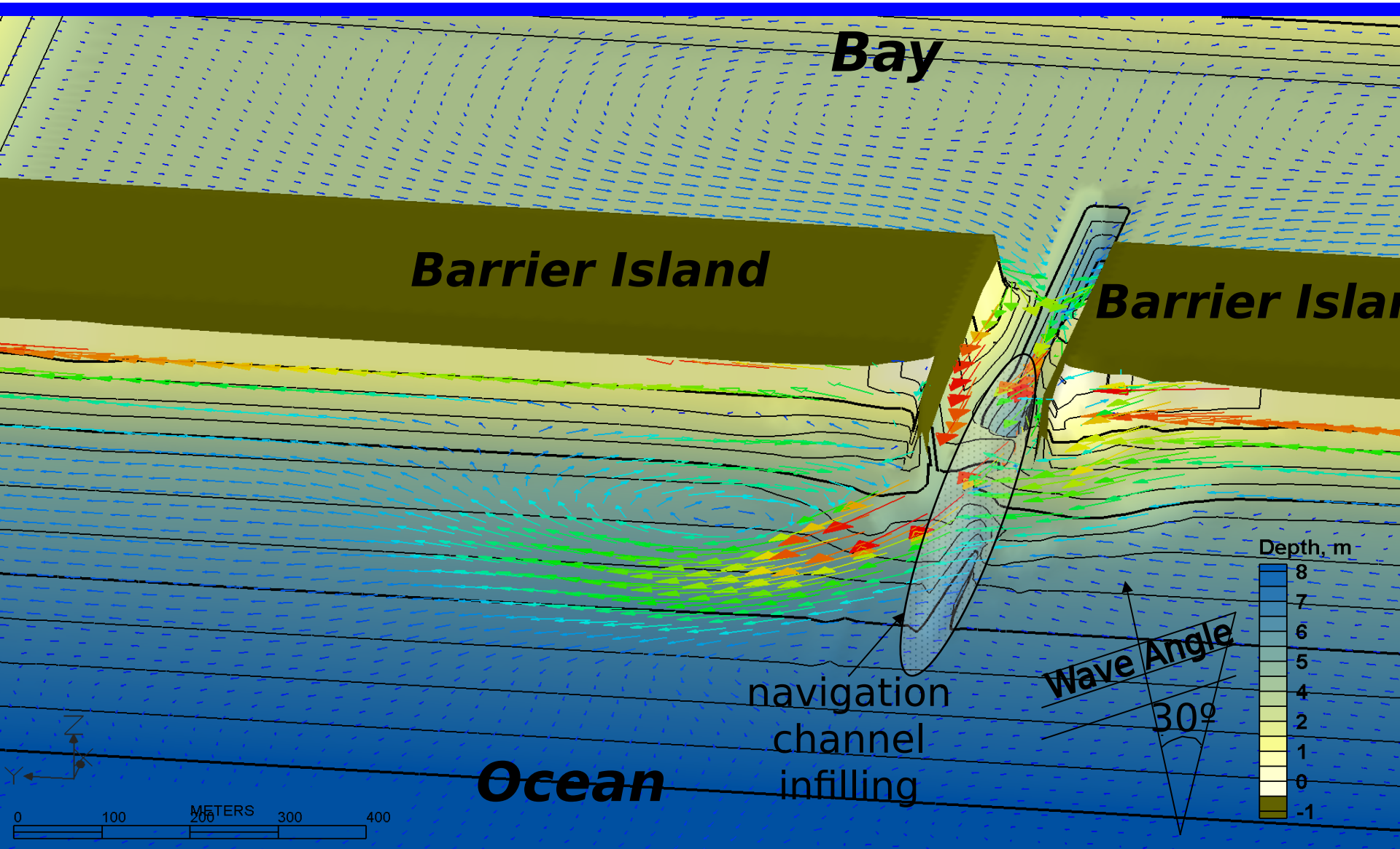
Designation	Height (m)	Period (s)	Direction (deg)
Typical	1	8	30
Storm	3	14	30
Shore normal	1	8	0
No waves (Tide forcing only)	N/A	N/A	N/A

Wave Angle:

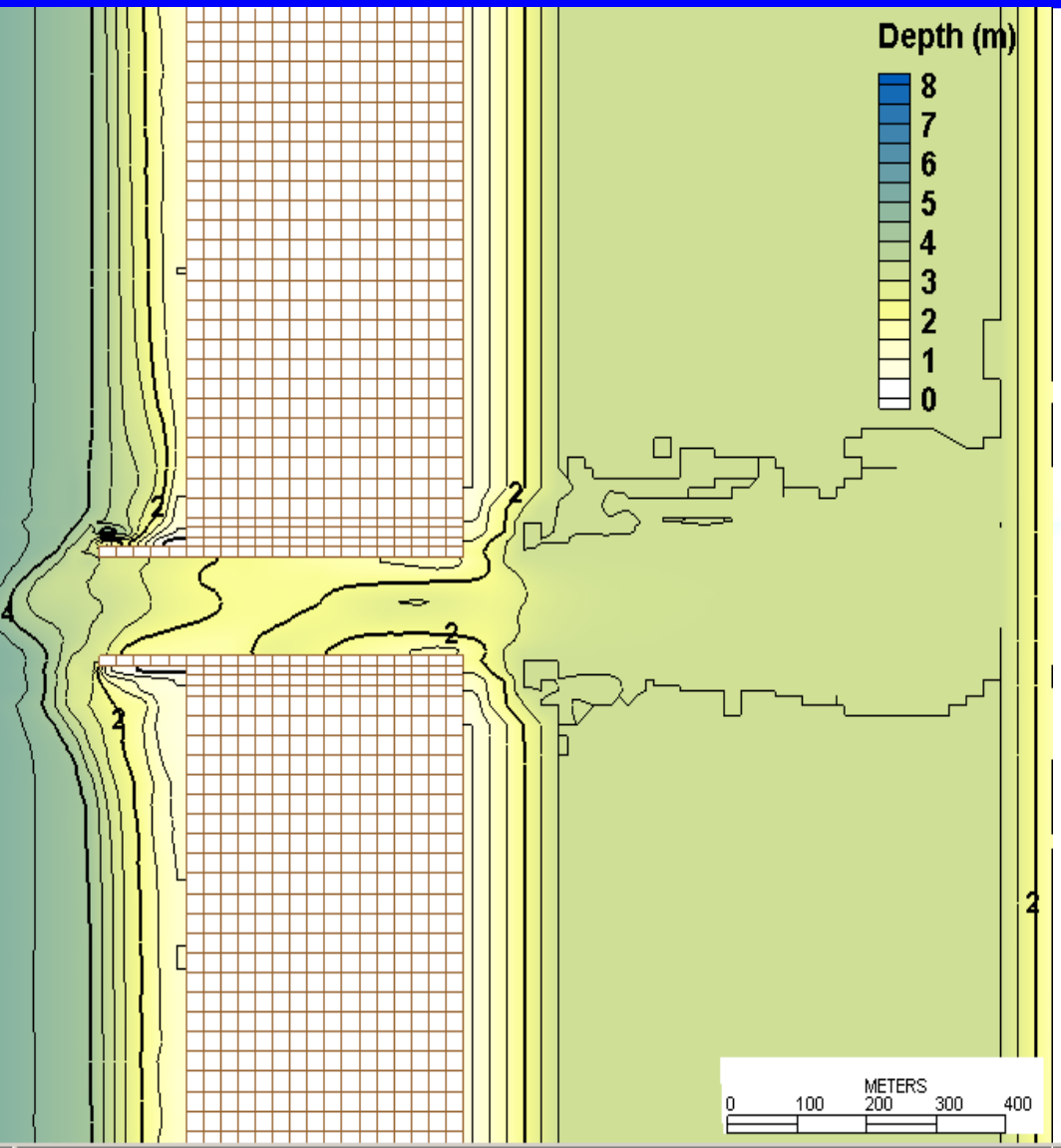


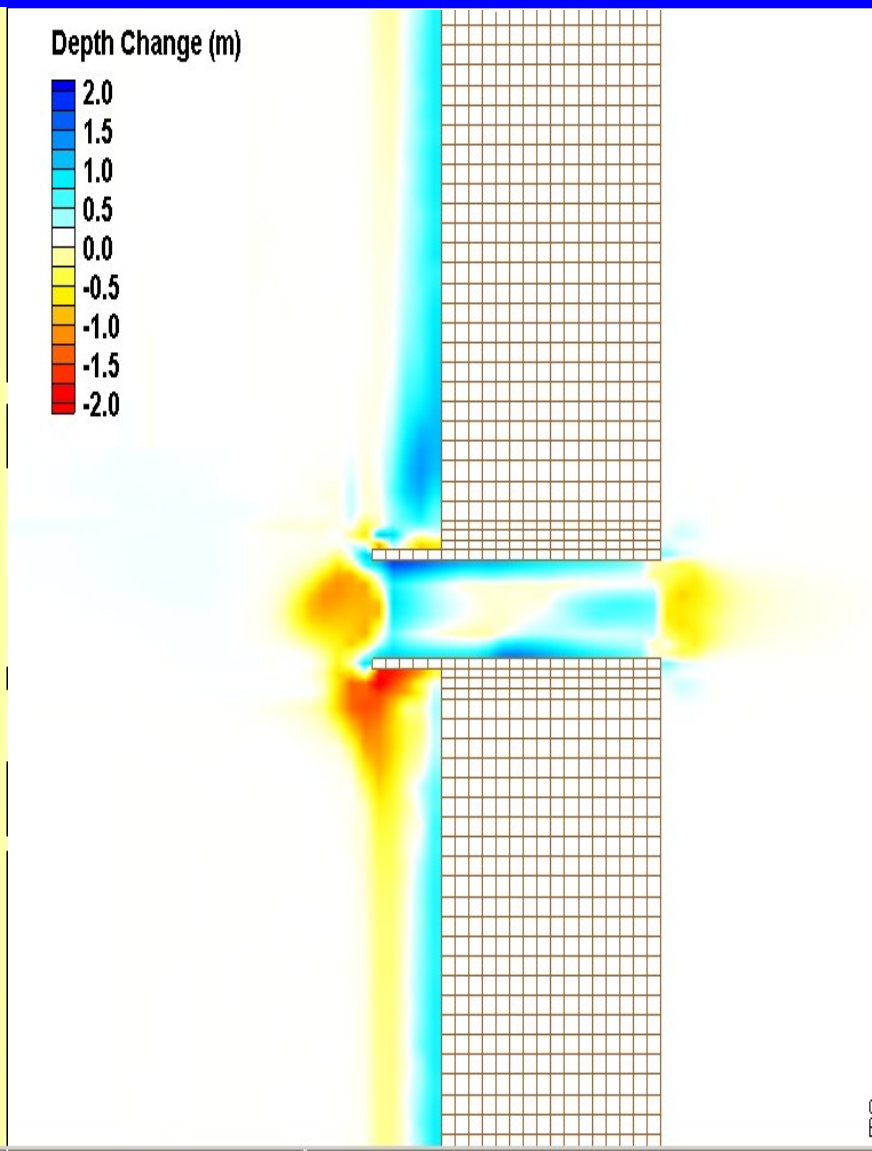


Results

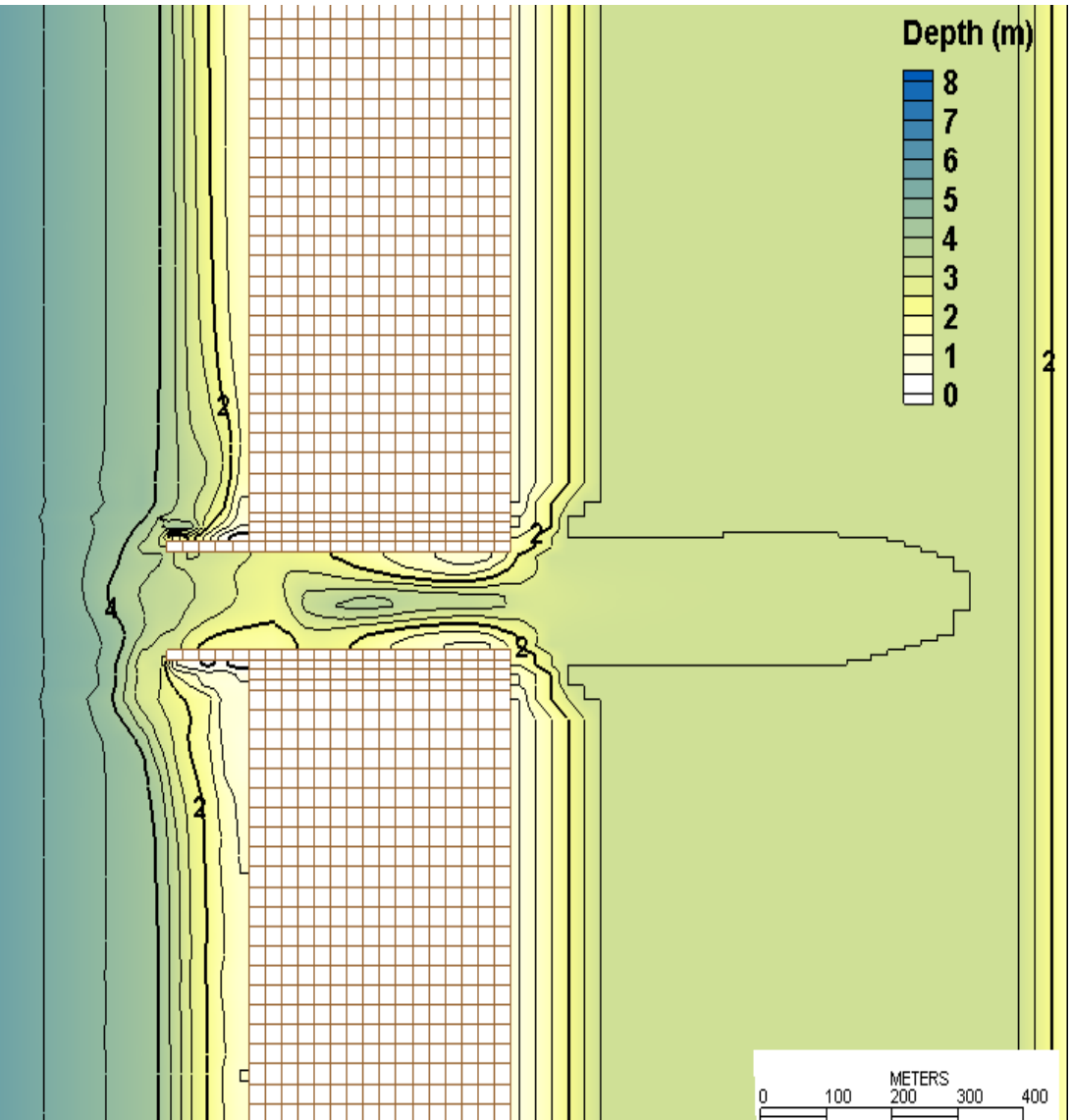

Bay
Barrier Island
Barrier Islan
navigation
channel
infilling
Ocean
Wave Angle
30º
Depth, m
8
7
6
5
4
2
1
0
-1
0
100
200
300
400
METERS

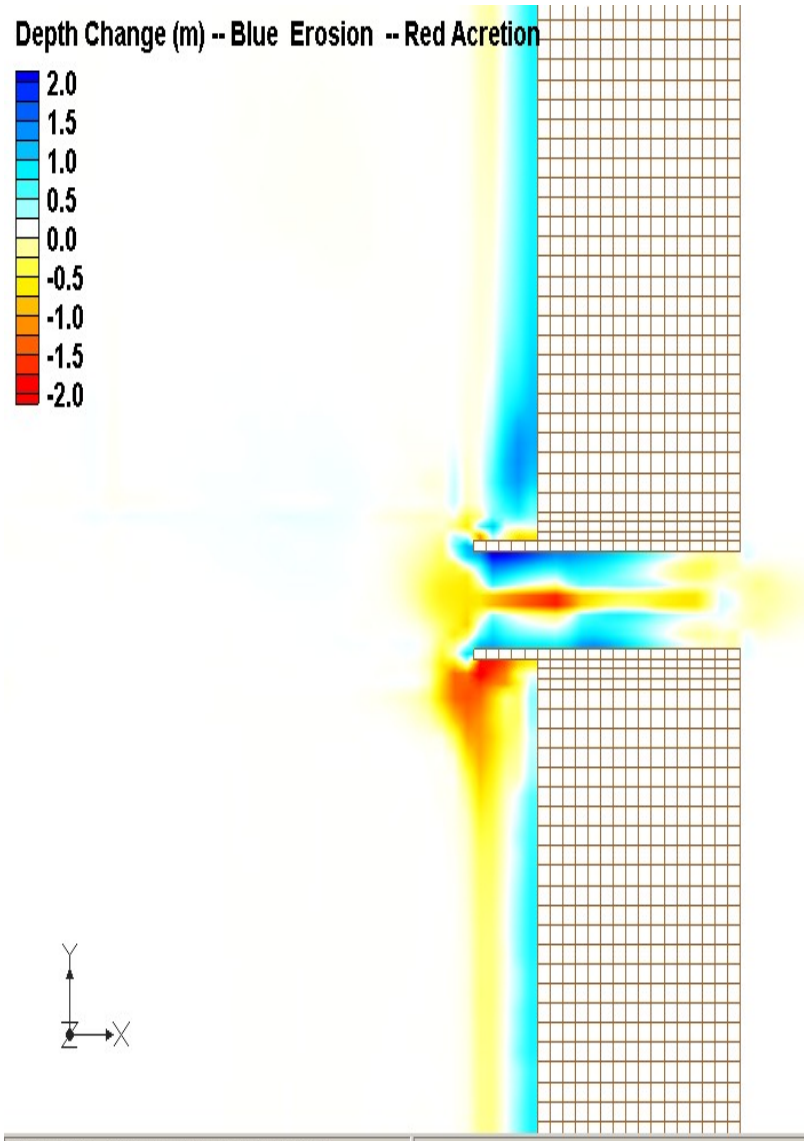
2 m Channel, Typical Waves



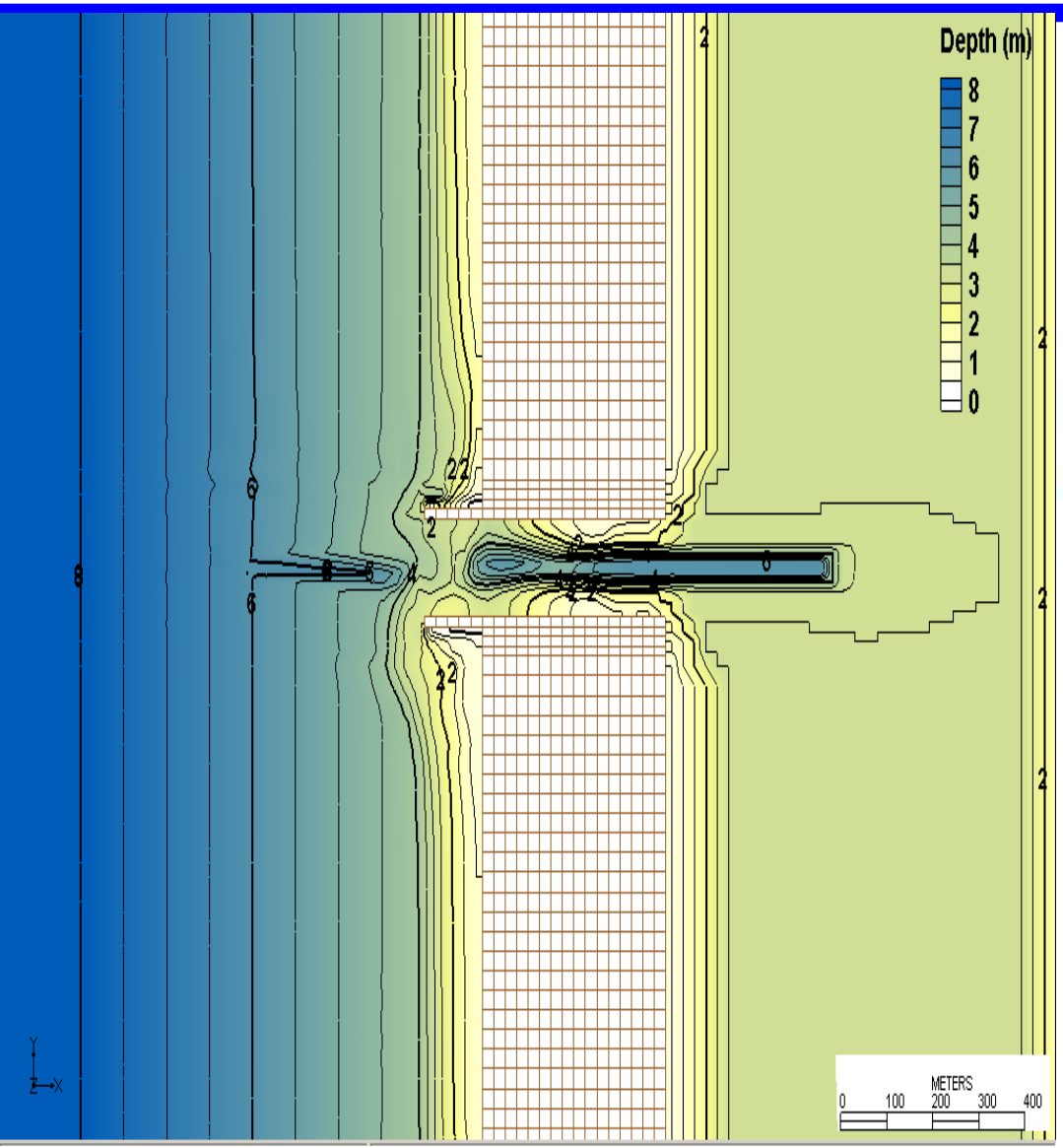


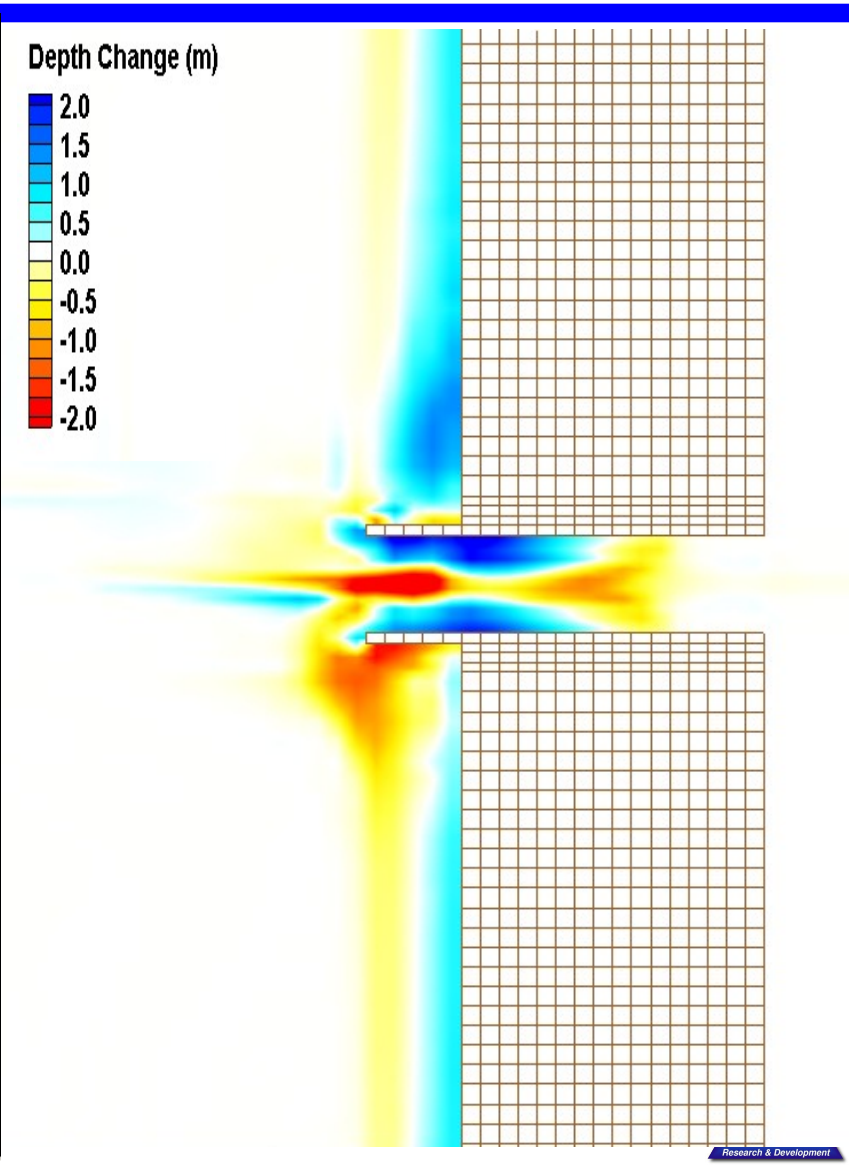
4 m Channel, Typical Waves



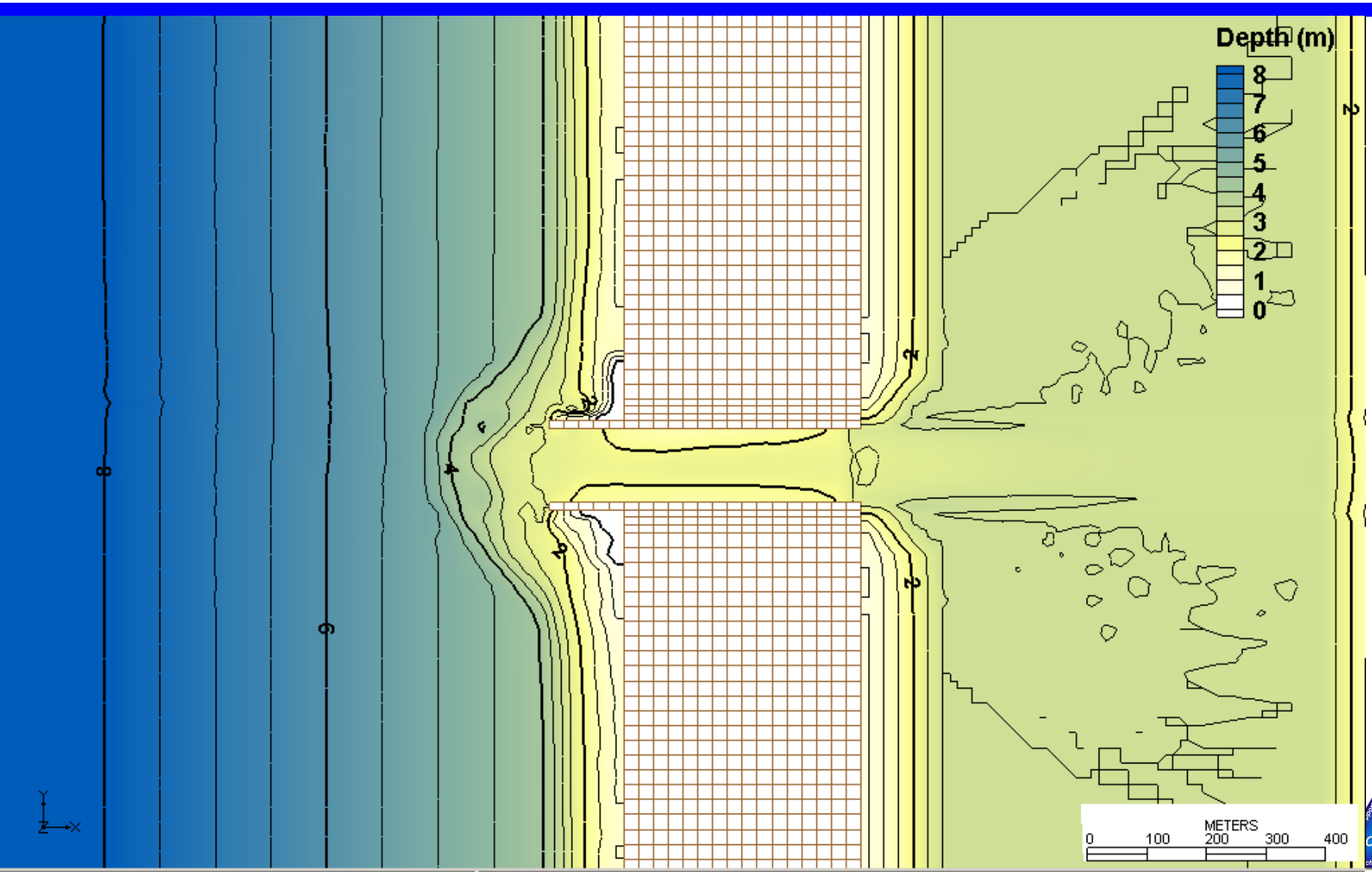


6 m Channel, Typical Waves

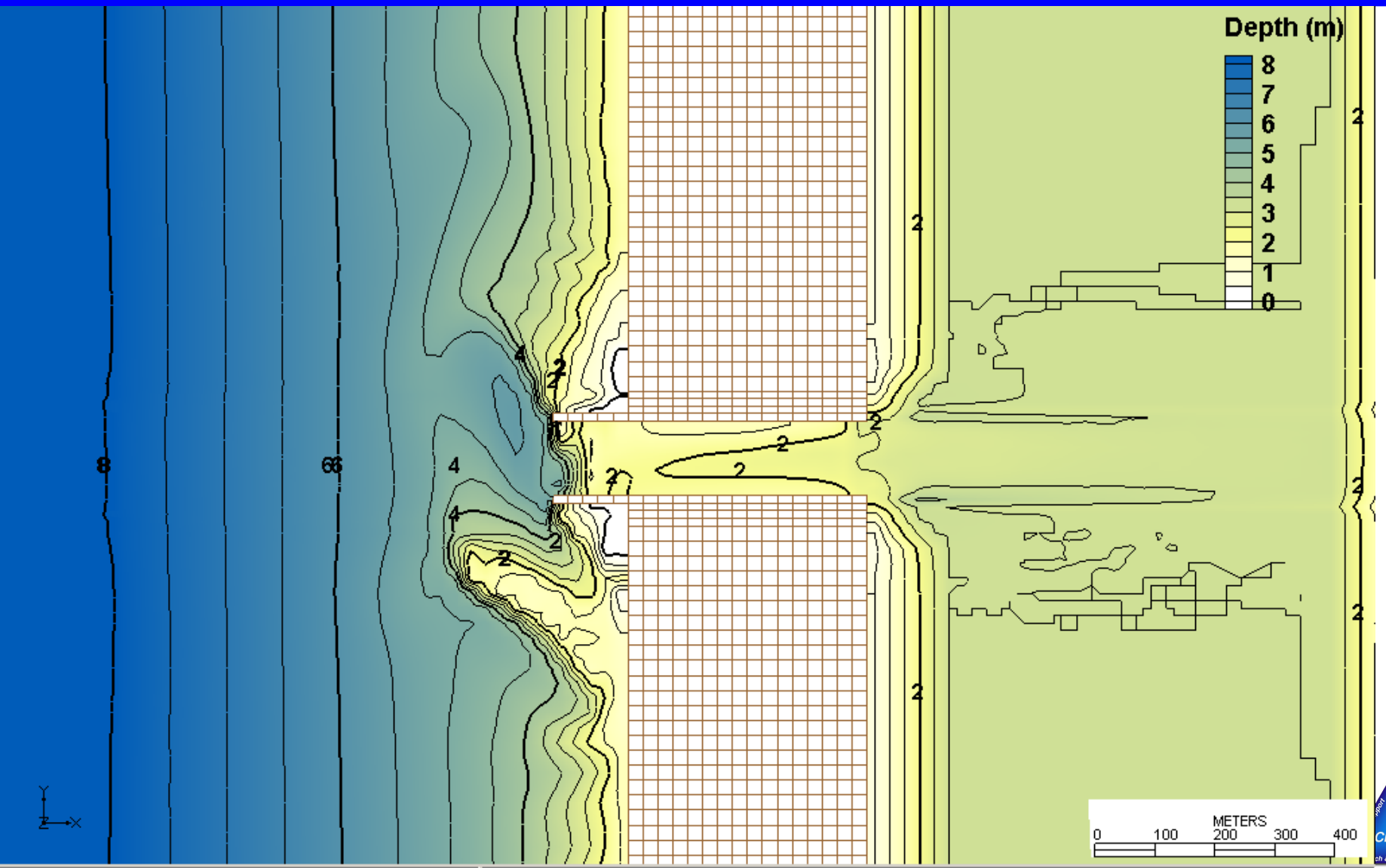




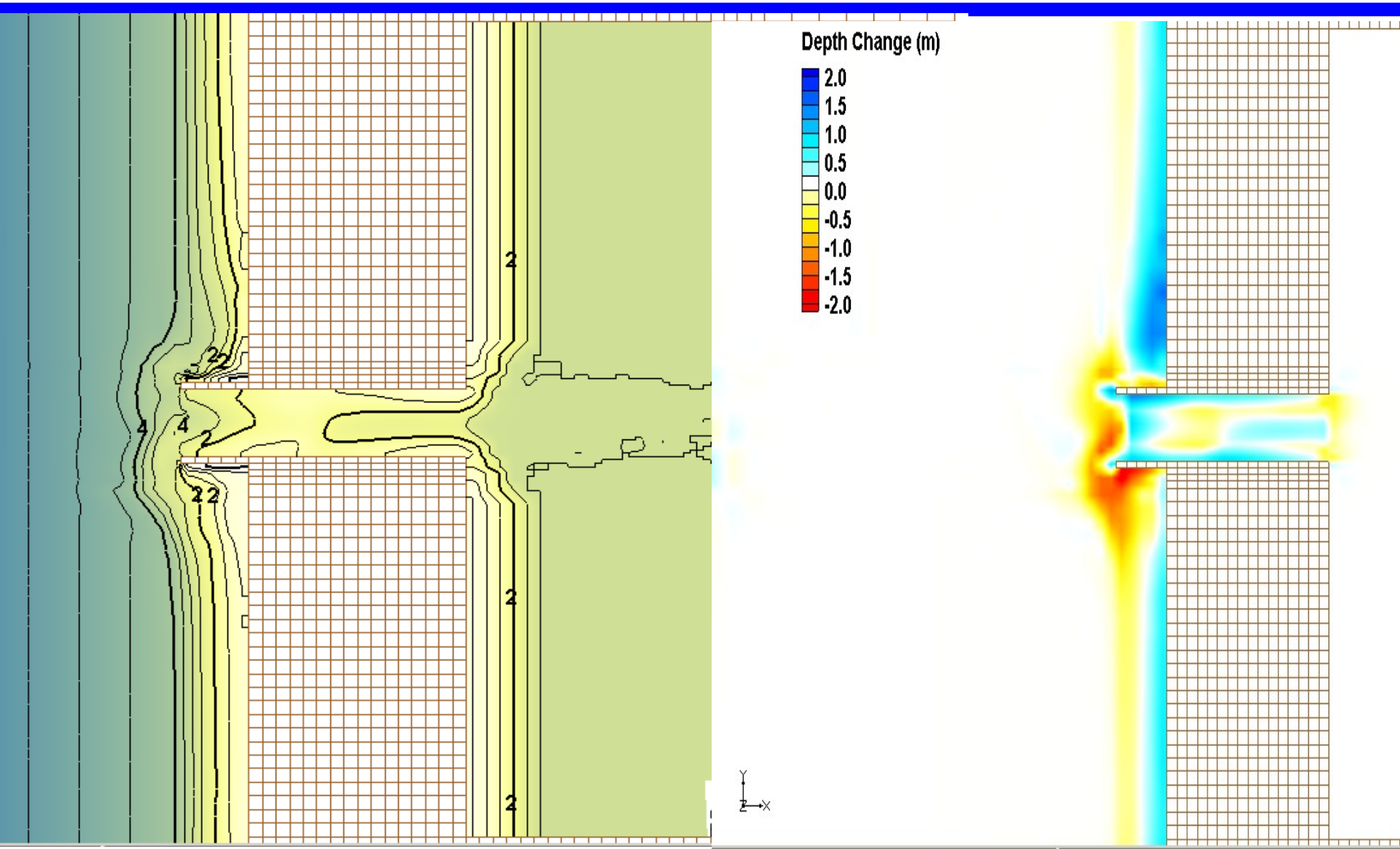
2 m Channel with Equilibrium Bar, Typical Waves



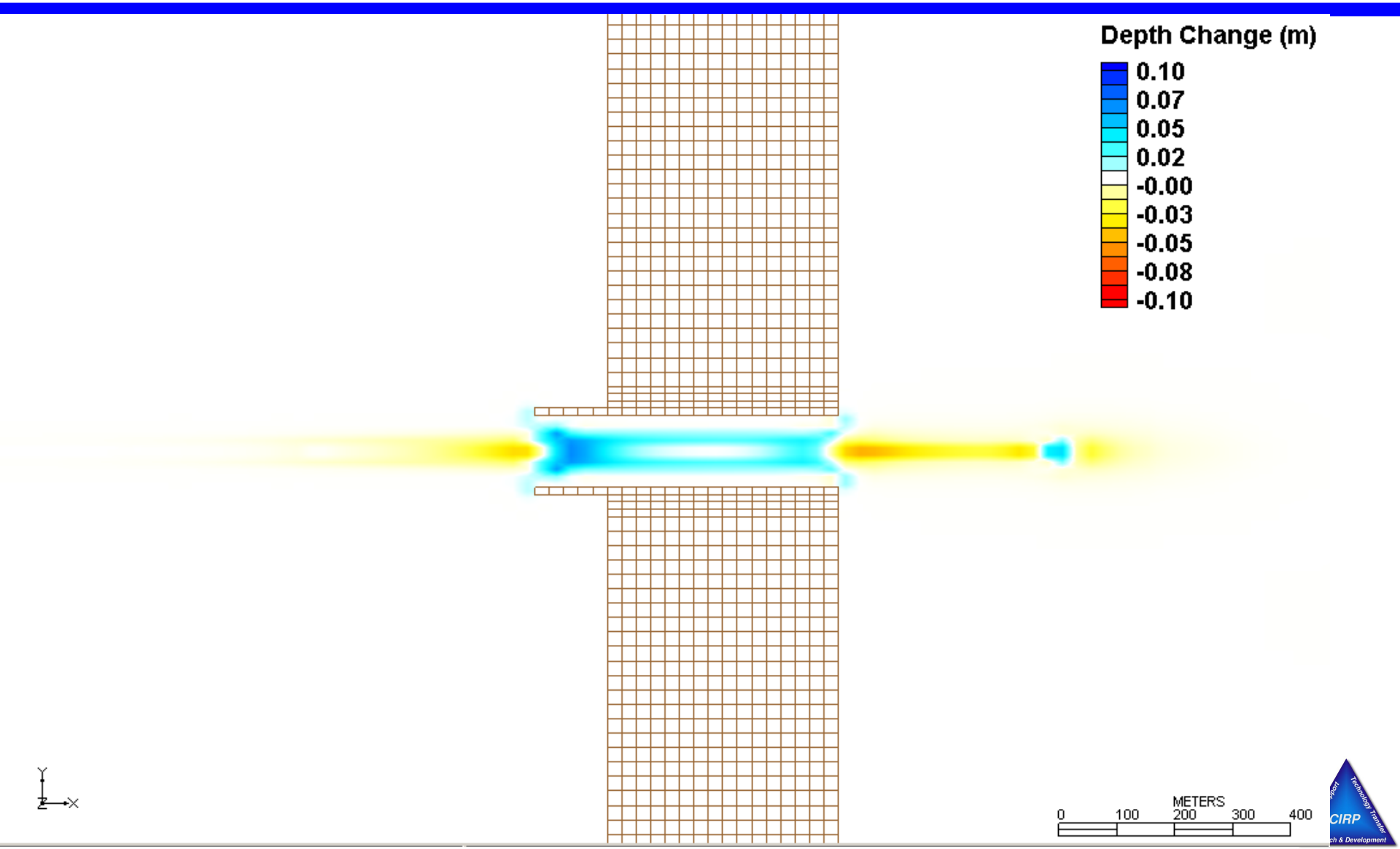
2 m Channel with Equilibrium Bar, Storm Waves

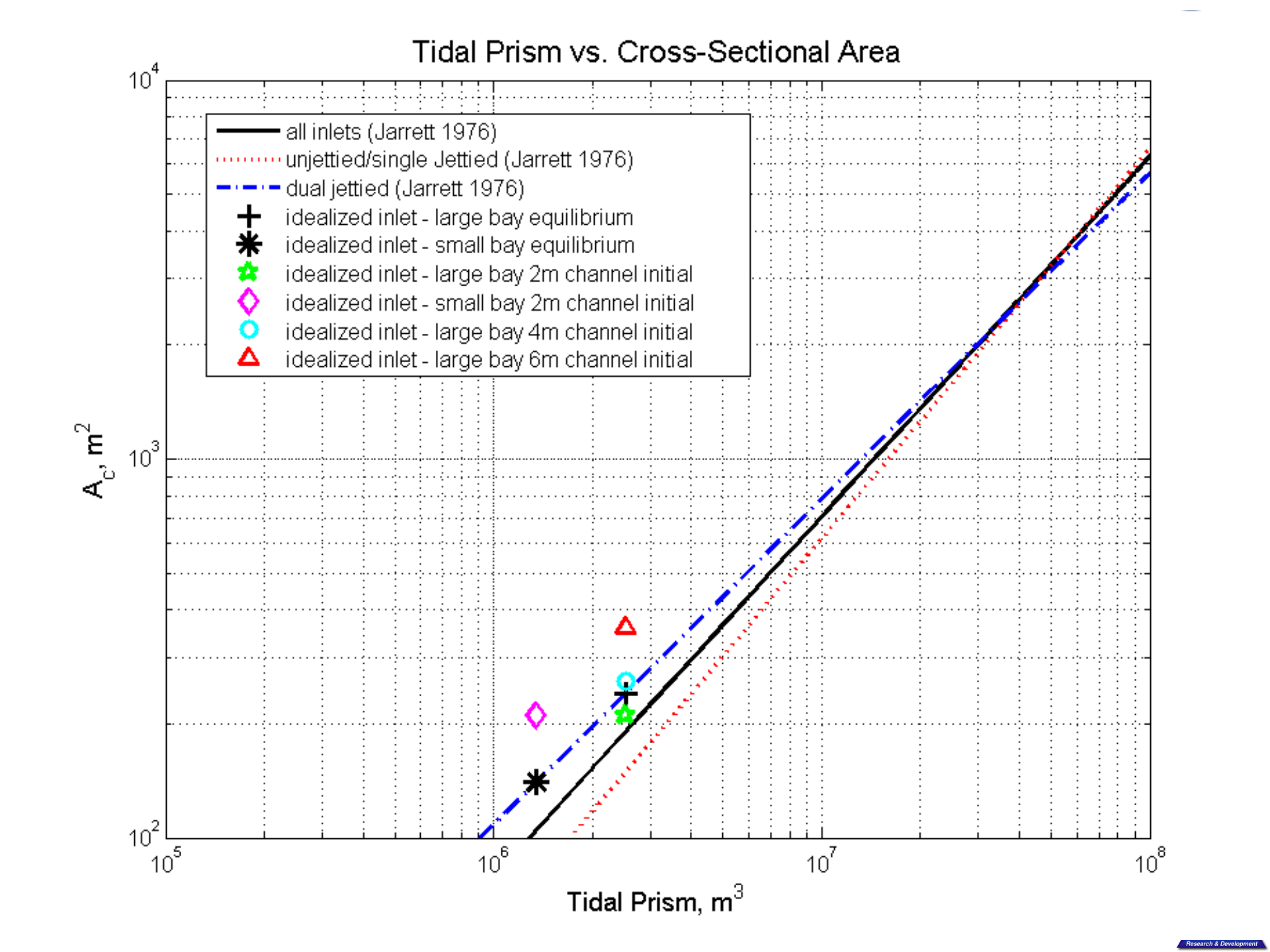


2 m Channel with Reduced Bay Area, Typical Waves



6 m Channel, No Waves (Tide Only)




Tidal Prism vs. Cross-Sectional Area
all inlets (Jarrett 1976)
unjettied/single Jettied (Jarrett 1976)
dual jettied (Jarrett 1976)
idealized inlet - large bay equilibrium
idealized inlet - small bay equilibrium
idealized inlet - large bay 2m channel initial
idealized inlet - small bay 2m channel initial
idealized inlet - large bay 4m channel initial
idealized inlet - large bay 6m channel initial
A_c, m^2
Tidal Prism, m^3
10^2
10^3
10^4
10^5
10^6
10^7
10^8

Concluding Remarks

- Morphologic features systematically linked to channel morphology
- Storm condition bypassing occurs at greater depths due to increased depth of closure under the large wave regime
- Numerical modeling of channel infilling, migration, and sediment bypassing is becoming more reliable

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Acknowledgements

- PIANC USA
  - John Paul Woodley, Jr. – Chairman
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  - Bruce Lambert – Secretary
  - Edmond J. Russo, Jr. – Publications Chairman

- Coastal Inlets Research Program (CIRP)
  - Nicholas C. Kraus – Program Manager
  - Jack Davis, Jim Clausner – Technical Directors

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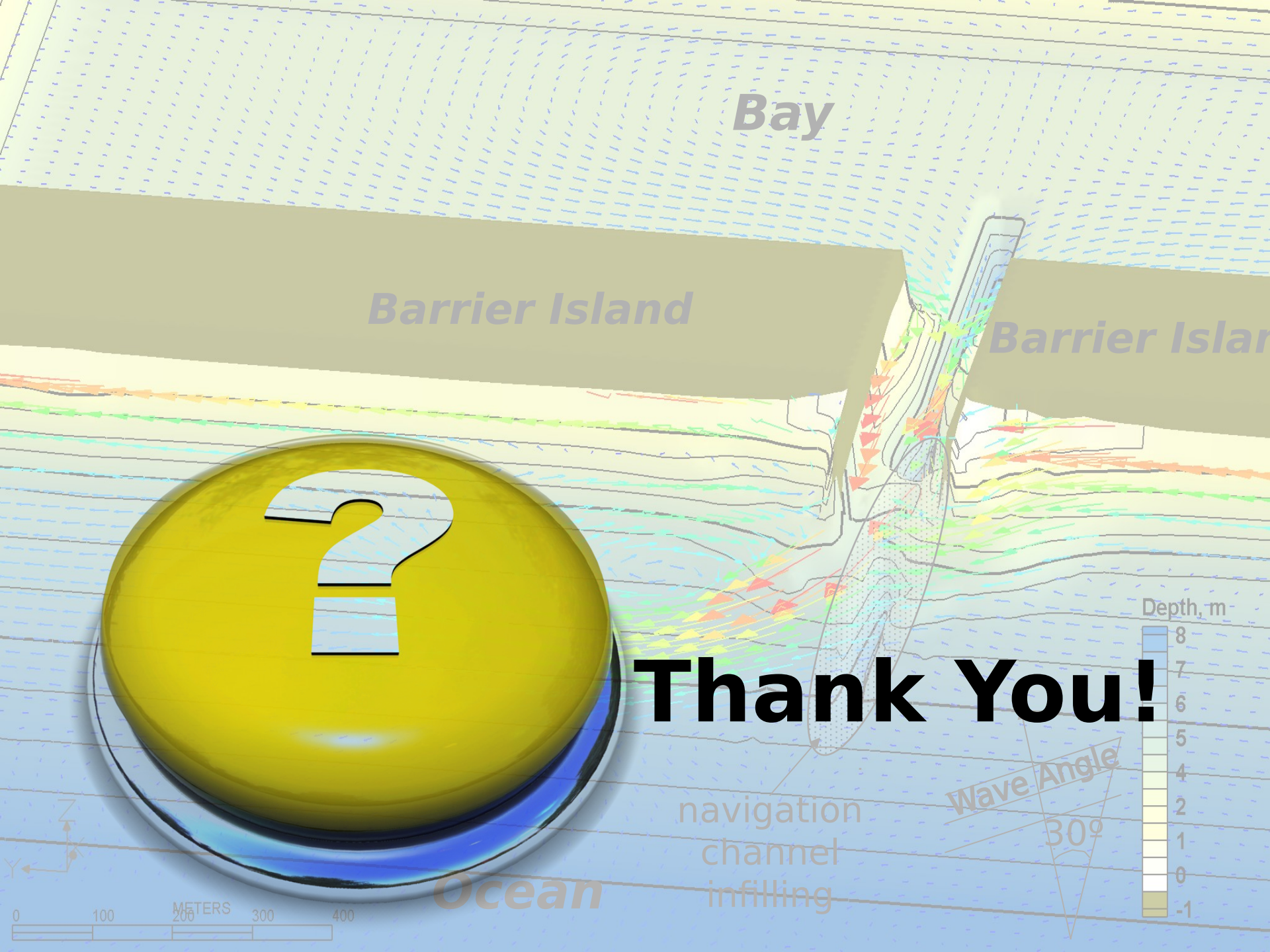
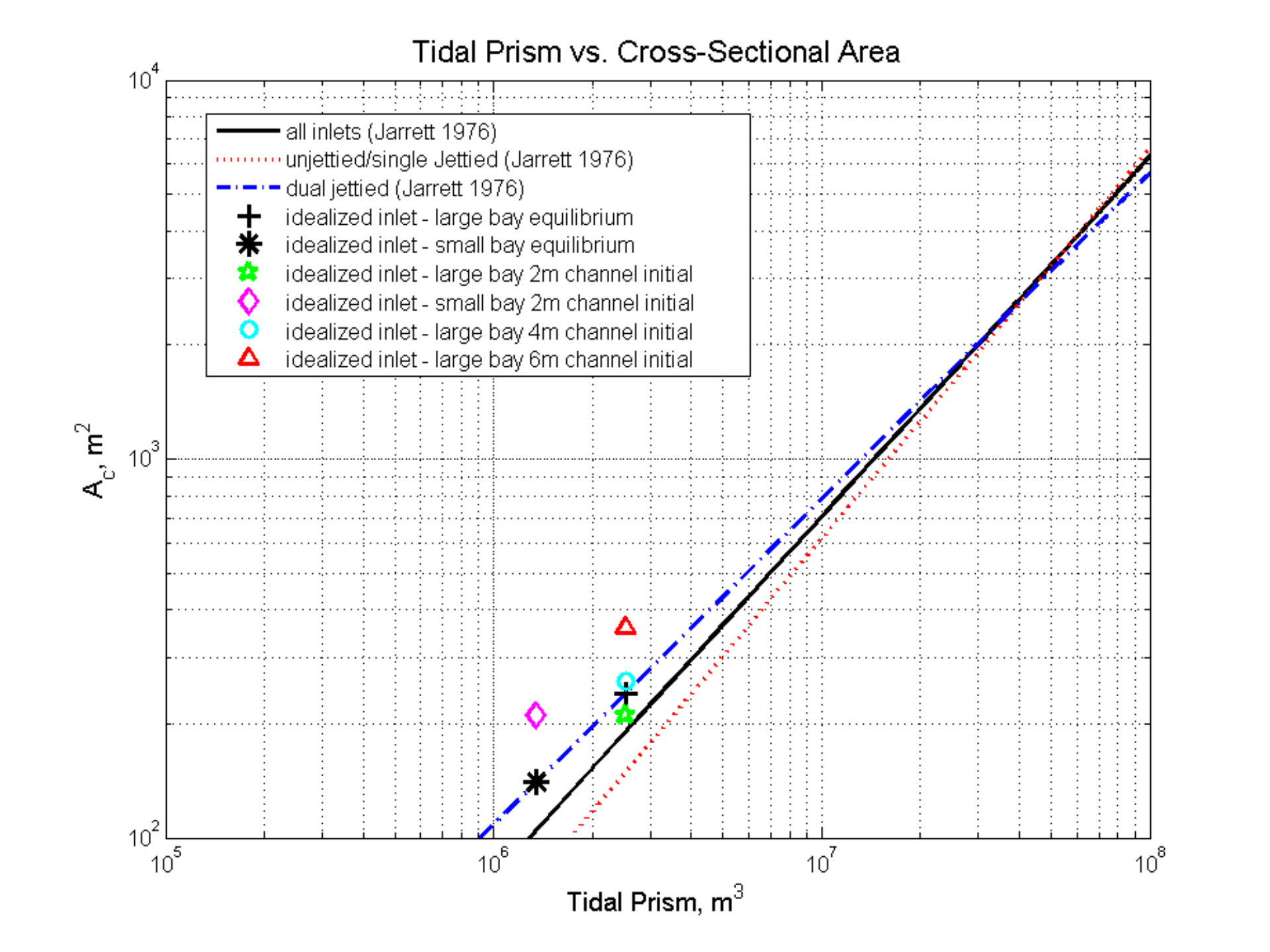

Bay
Barrier Island
Barrier Islan
Depth, m
8
7
6
5
4
2
1
0
-1
Wave Angle
30º
navigation
channel
infilling
Ocean
Z
Y
0
100
200
300
400
METERS

Thank You!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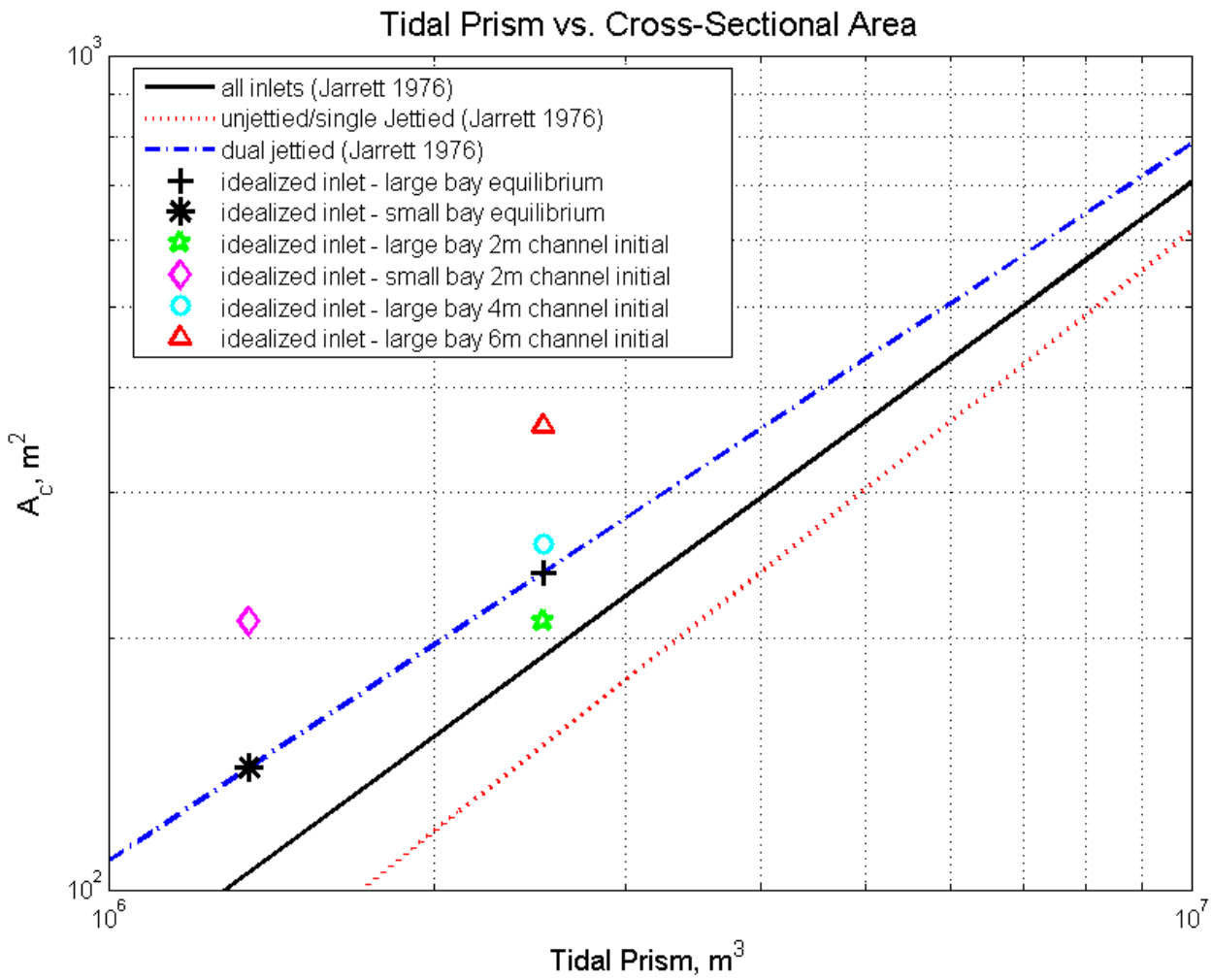
Tidal Prism, m^3
10^2
10^3
10^4
10^5
10^6
10^7
10^8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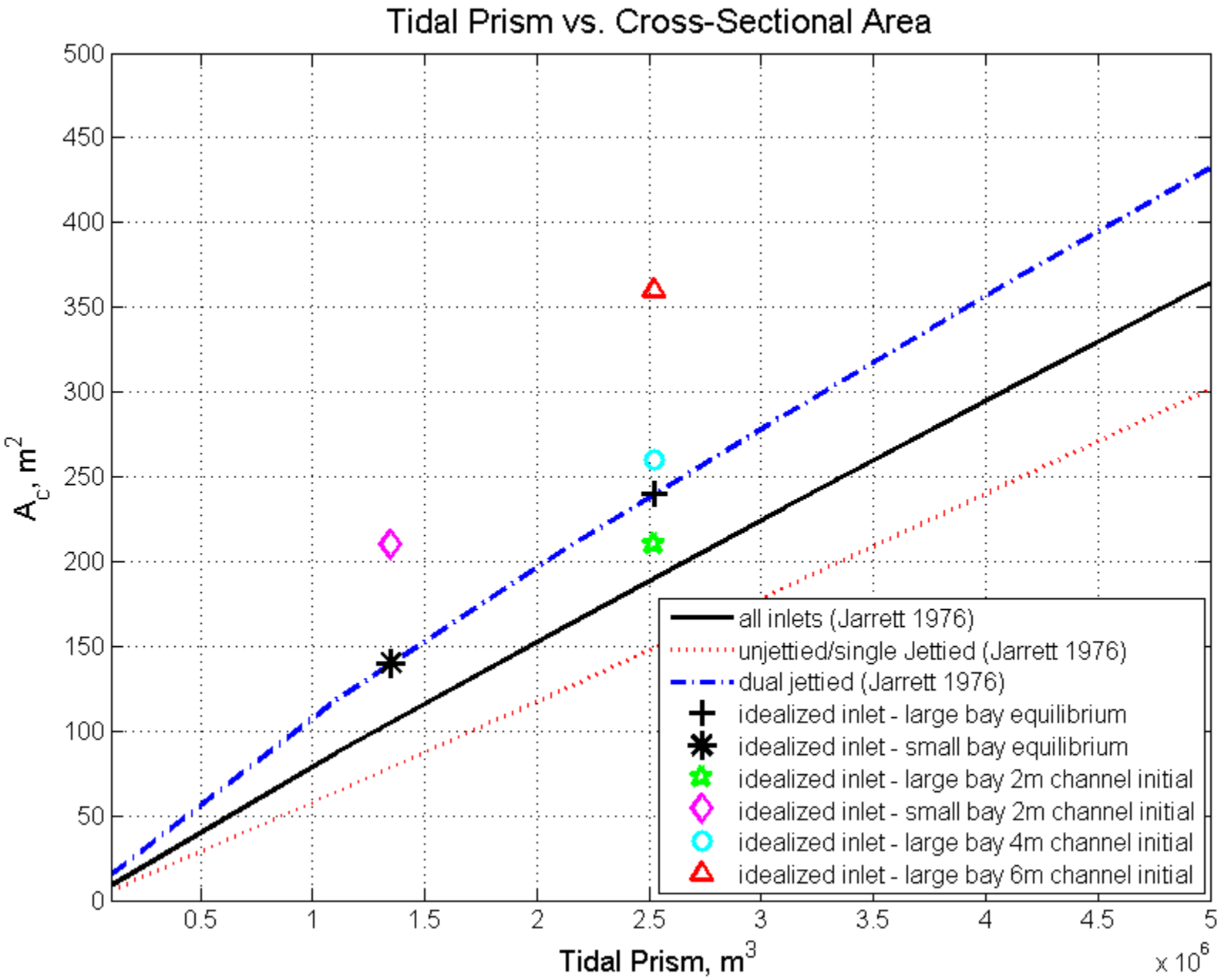
idealized inlet - large bay 6m channel initial
10^3
10^2
10^6
10^7
A_c, m^2
Tidal Prism, m^3


Tidal Prism vs. Cross-Sectional Area
A_c, m^2
Tidal Prism, m^3
x 10^6
0
50
100
150
200
250
300
350
400
450
500
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
all inlets (Jarrett 1976)
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idealized inlet - large bay equilibrium
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idealized inlet - small bay 2m channel initial
idealized inlet - large bay 4m channel initial
idealized inlet - large bay 6m channel initial

$$A_c = CP^n \qquad A_c = 3.76 \times 10^{-4} P^{0.86}$$

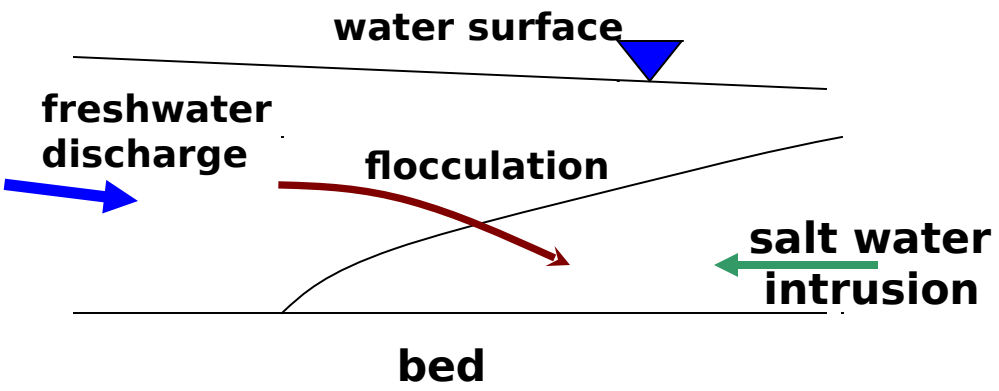
$$\frac{\partial (Cd)}{\partial t} + \frac{\partial (Cq_x)}{\partial x} + \frac{\partial (Cq_y)}{\partial y} = \frac{\partial}{\partial x}\left(K_x d \frac{\partial C}{\partial x}\right) + \frac{\partial}{\partial y}\left(K_y d \frac{\partial C}{\partial y}\right) + P - D$$

$$c_R = A_{cR} q_{cw,m} \exp\left[-b \frac{q_{cr}}{q_{cw}}\right]$$

$$\frac{\partial h}{\partial t} = \frac{1}{1-p}\left[\left(\frac{\partial q_{bx}}{\partial x} + \frac{\partial q_{by}}{\partial y}\right) + P - D\right]$$

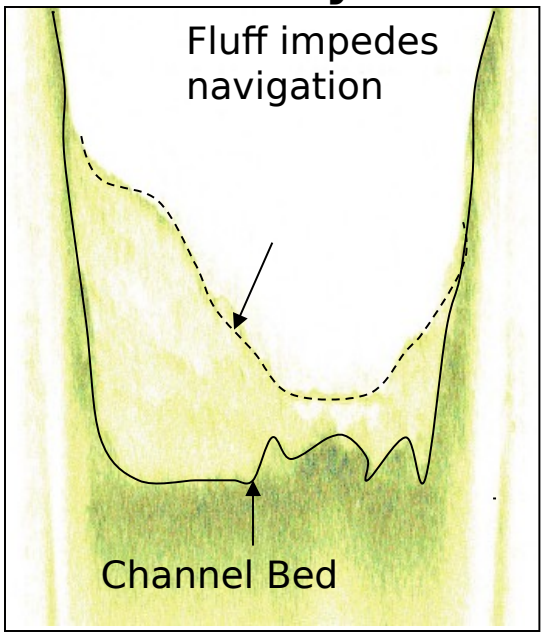
Cohesive Transport in Navigation Channels

Turbidity maximum



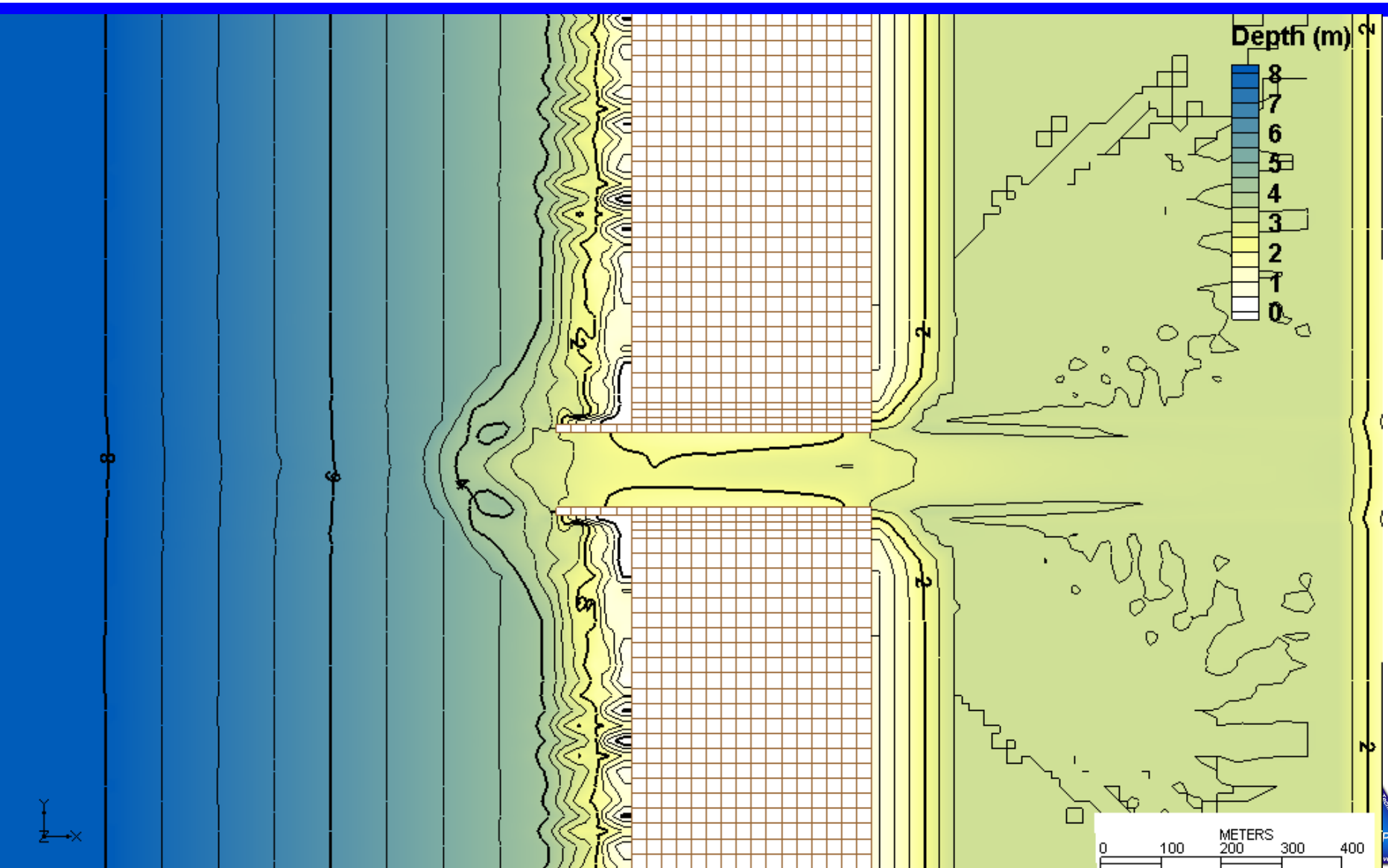
Important considerations in bays and sheltered areas were fine material is source of channel infilling

Hindered settling 'fluff layer'



Matagorda Ship Channel, TX

2 m Channel with Equilibrium Bar, Shore Normal Waves



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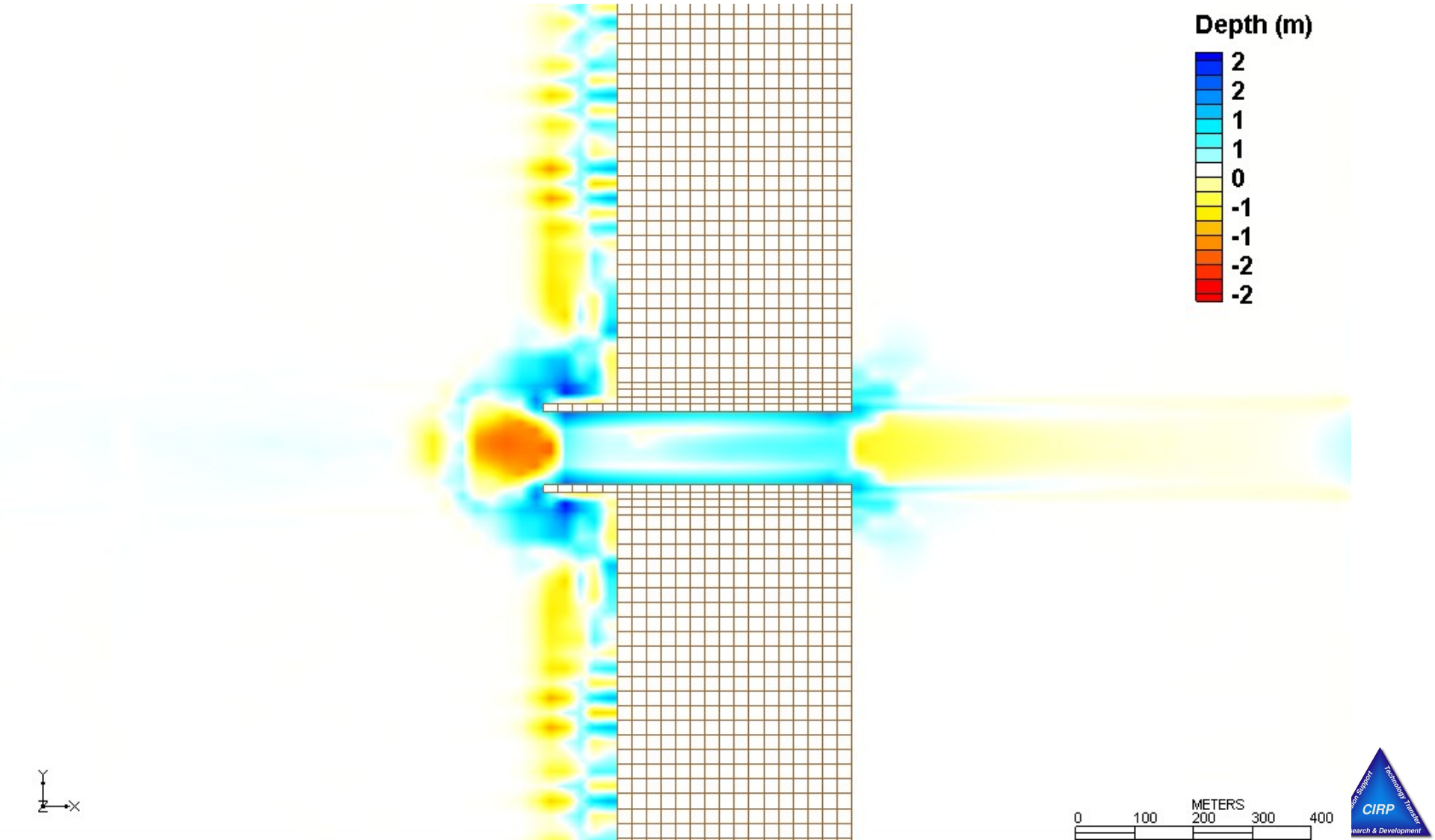
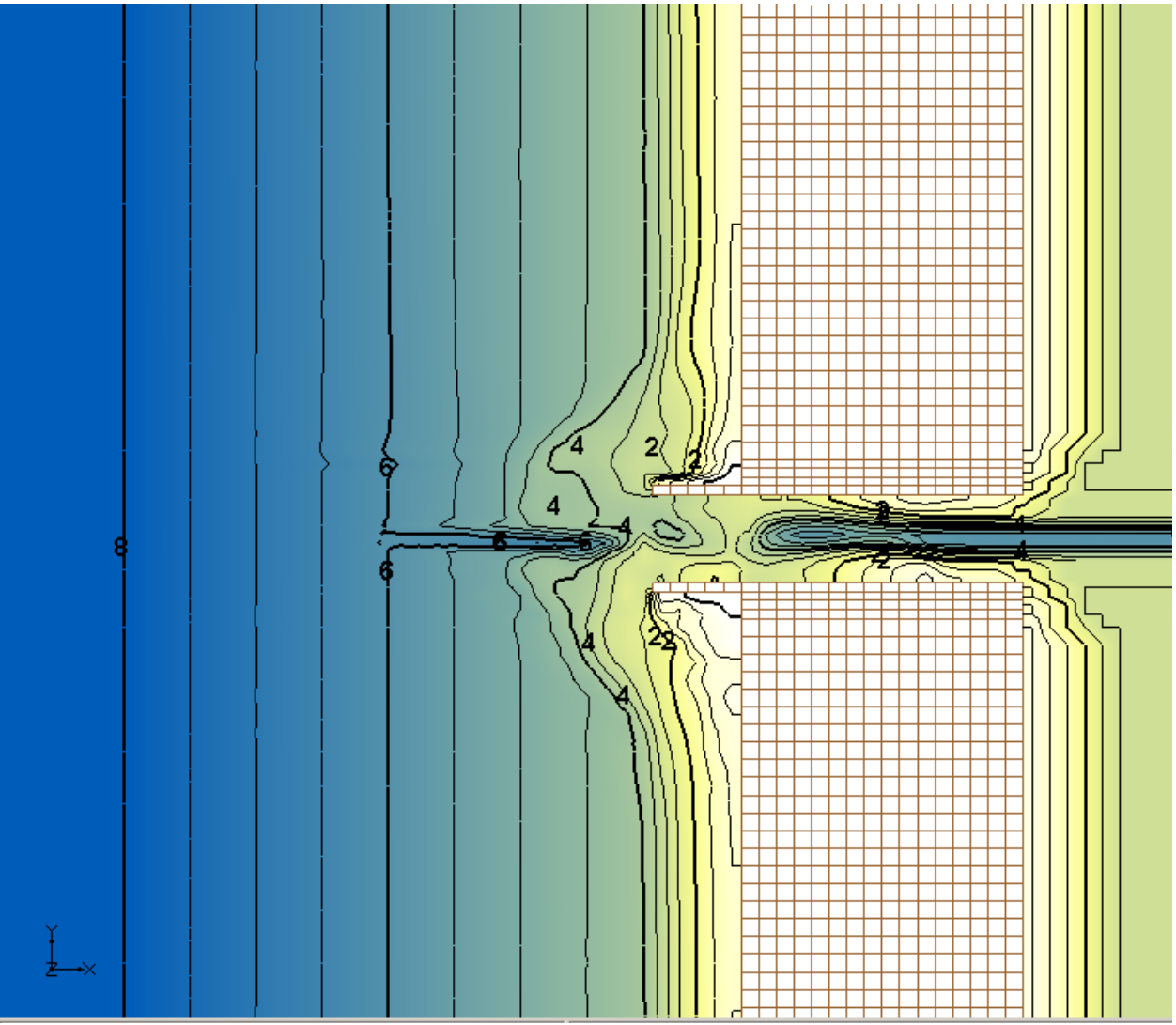
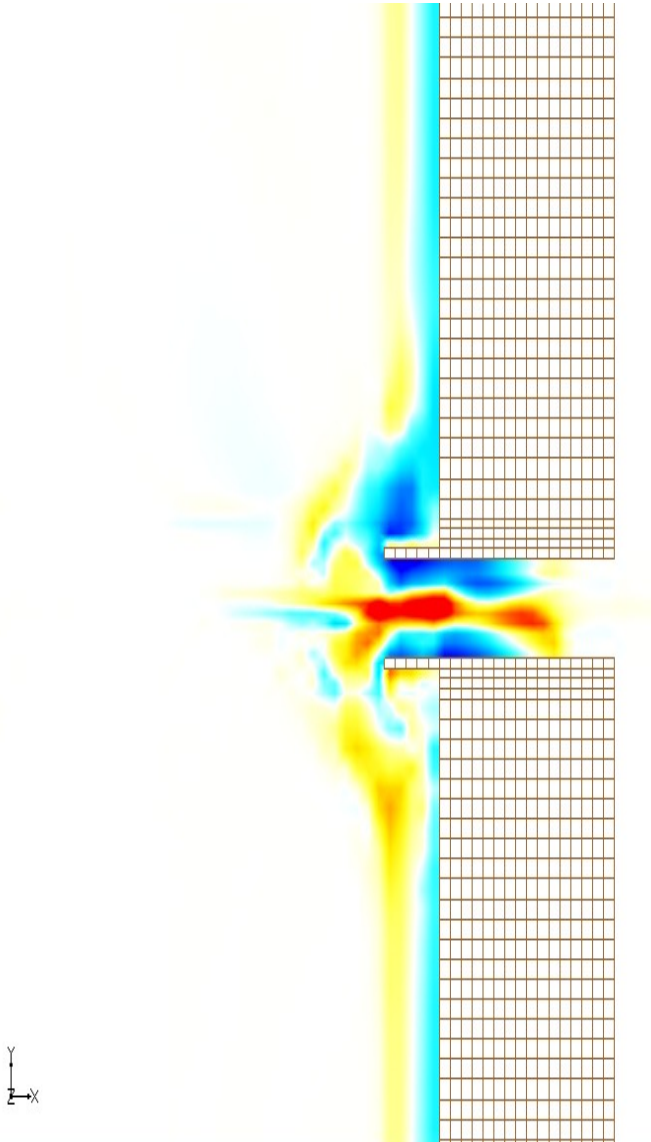
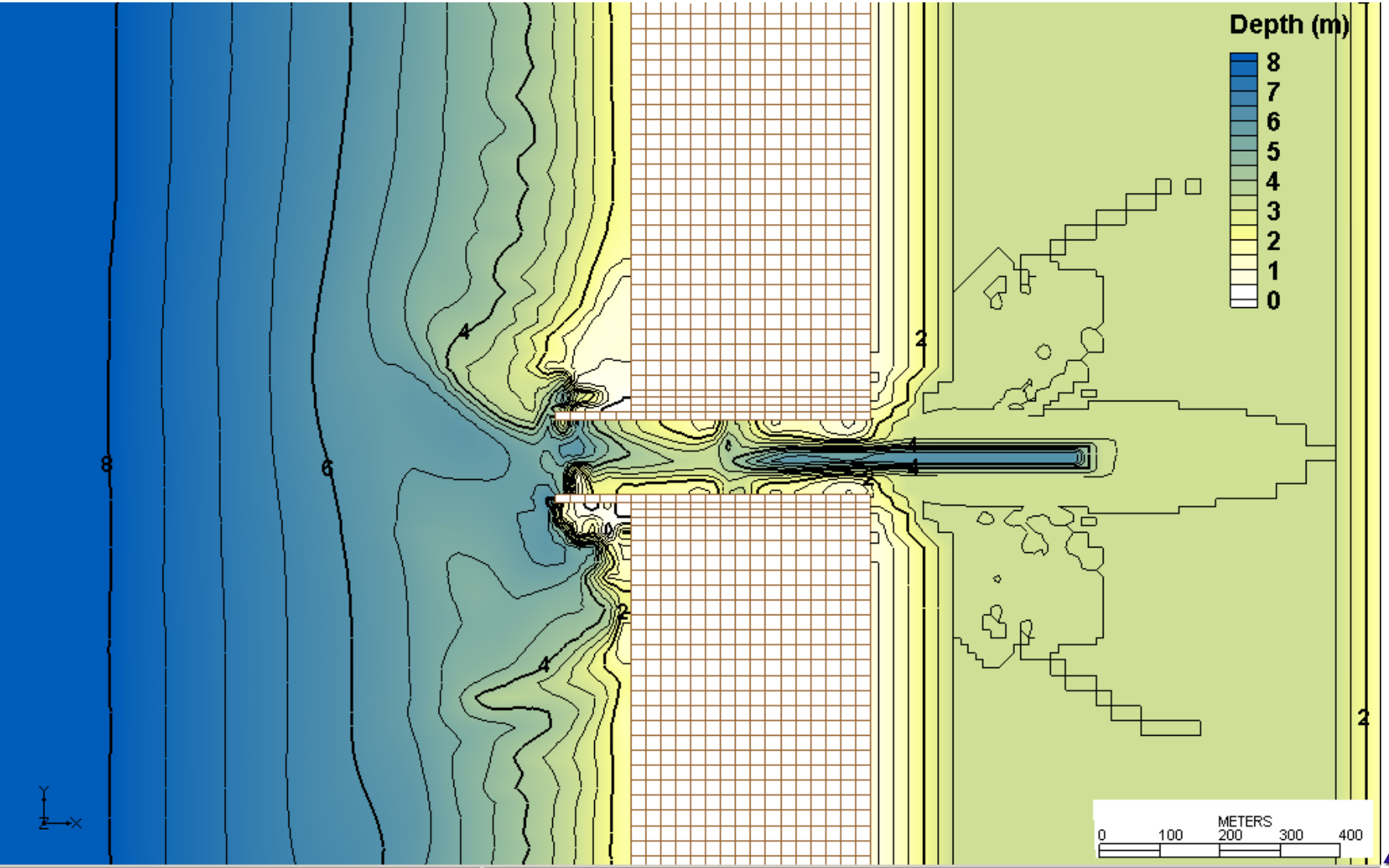


6 m Channel with Equilibrium Bar, Typical Waves

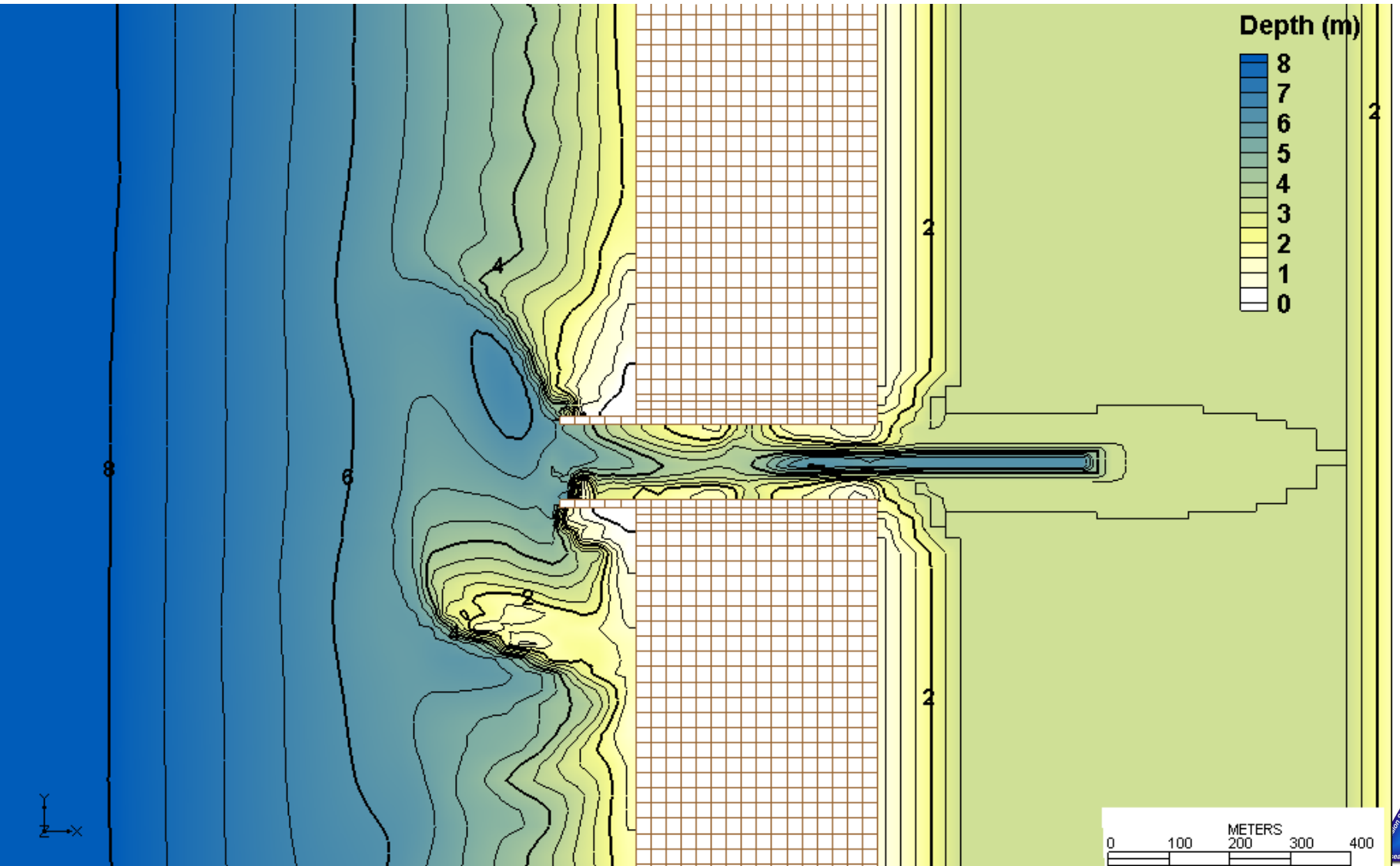




6 m Channel, Storm Waves



6 m Channel with Equilibrium Bar, Storm Waves



2 m Channel, Storm Waves